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EFFECT OF MACHINE SPEED ON YARN INPUT TENSION AND 'ON-MACHINE' COURSE LENGTH FOR A CIRCULAR WEFT KNITTING MACHINE WITH POSITIVE STORAGE FEEDING

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ABSTRACT

The effect of machine speed on yarn input tension and course length has been observed at two different loop sinking depths through cam settings for an industrial single jersey circular weft knitting machine producing plain jersey fabric with spun polyester yarns. Linear regression analyses representing the relationship between the mentioned variables were evaluated. Yarn input tension and course length were found to vary positively with machine speed resulting a r-square value of more than 0.9. A rise in dynamic coefficient of friction also supported the finding. It was also observed that the estimated change in course length for a single unit change in yarn input tension remained almost same though tension values might differ significantly at different cam settings.

***KEYWORDS:** Knitting Machine, Machine Speed, Positive Storage Feed, Yarn Input Tension, Course Length & Linear Regression*

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Original Article

INTRODUCTION

Knitting is the second most popular technique of fabric formation where the construction is built up by intermeshing of yarn loops (Ray, 2012). It is very much common for a knitted fabric manufacturer to target higher production without unacceptable faults in the process. Considering the performance influencing factors (Iyer, Mammel and Schäch, 1995) a knitted fabric manufacturer may find out several ways to increase the production of a particular circular weft knitting machine, for example, changing yarn count, stitch length or machine speed. As yarn count and stitch length are very much interrelated with fabric dimension and performance (International Institute for Cotton, 1988), machine speed is the ultimate choice for a knitter to control production rate of a particular fabric quality. However, maximum limit of machine speed is fixed by the knitting machine manufacturer for a particular model through circumferential speed (Spencer, 2001). On the other hand a knitter determines the maximum limit of production speed considering mainly rise in yarn tension, which breaks the yarn and creates several process troubles (Koo, 2002). Yarn tension also influences the 'on-machine' course length of fabric that is measured on running yarn and can be used to determine the actual course length or loop length in the fabric precisely (Hossain and Ali, 2017).

The present work is thus aimed to evaluate the influence of machine speed over yarn input tension and 'on-machine' course length for a modern circular weft knitting machine that operates with a 'quality' yarn delivery

system like positive storage feed device.

THEORETICAL BACKGROUND

A Knitted garment (Figure 1) is made from knitted fabric (Figure 2) which is built-up by interlooping of yarns using needles. In weft knitting, loops made by each yarn are formed substantially across the width of the fabric.

Figure 1: A Knitted t-shirt ("Stone Washed t-shirt",n.d.)

Figure 2: Some Knitted Fabrics ("Knitted Wool Fabric",n.d.)

A simple flowchart of circular weft knitting process practiced in an industry may be shown as:.

Yarn in package form
↓
Feeding the yarn
↓
Machine setting for required design and quality
↓
Knitting of the fabric

Course length is the most important parameter that determines the dimensions of the knitted fabric (Lek-Uthai and Dias, 1999). Course length can be obtained from a knitted fabric by measuring the uncrimped length of an unraveled course, i.e., row of loops around the circumference of a circular knitted fabric (Figure 3). However as course is formed by one revolution of the needle cylinder during dynamic circular knitting process (Figure 4), measurement of course length on running yarn or 'on-machine' course length measurement through a portable hand-held instrument is generally preferred by a knitter instead of time-consuming and destructive off-machine measurement as stated earlier.

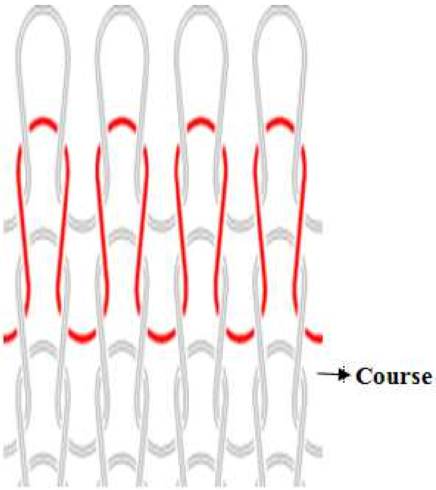


Figure 3: Intermeshed Yarn Loops in a Knitted Fabric ("Structure of Stockinette", n.d.)

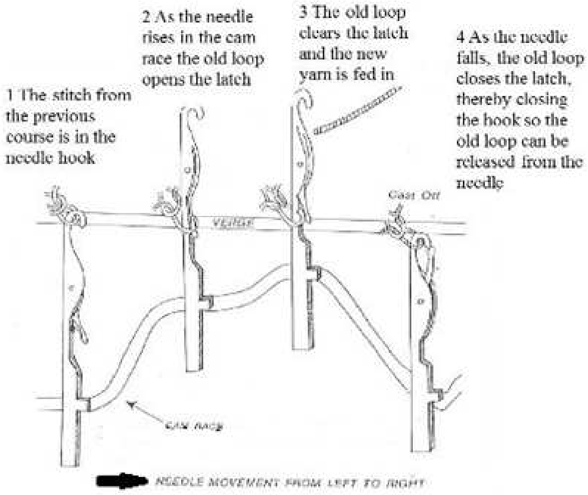


Figure 4: A Schematic Diagram of Loop Formation Steps of a Latch Needle When It Travels Through the Cam-race of a Knitting Cam ("Needles", n.d.)

Tension build-up on running yarn during knitting operation also plays a vital role as it influences knittability (i.e. the ability to knit faultless fabric) of the machine. Moreover yarn input tension (the tension under which yarn is delivered into the loop forming elements) may affect the amount of yarn fed required for the loop formation process thereby influencing fabric dimensions and other properties including weight (Knapton And Munden,1966; Elkarsany and Magboul, 2014). Though improved yarn delivery systems like positive storage feed device has been developed over the time to regulate course length (length of yarn used in the formation of one course of loops) as well as yarn tension, some factors like yarn property or machine setting may still incorporate variation in yarn input tension (Lek-Uthai and Dias,1999). Among the machine related parameters, speed of the needle bed (known as machine speed also) for positive storage feeding has not yet been studied elaborately as a tension or course length influencing factor by the researchers. A literature survey on this issue may reveal the outcomes of some relevant research works carried out till now.

Henshaw (1968) carried out experiments on a small (around 3.5-inch) diameter single cylinder knitting machine without positive feed device. He found no change in course length for the experimental machine speed ranging from 31 to 260 rpm.

Oinuman (1984) investigated on the the effects of some factors that are responsible for knot-related knitting defects for a double jersey circular weft knitting machine equipped with a positive-yarn-feeding device (IRO system). He also did some experiments on the effect of machine speed on loop length (loop length is obtained through dividing course length by number of needles in the machine) and could not find any mentionable influence.

Koo (2002) developed a sample test rig for the experimental purpose, which simulated the yarn path on the circular knitting machine. As a part of his research work, he investigated on yarn feeding speed rather than machine speed and found no distinct correlation of yarn tension with the feeding speed. He also found that yarn feeding angle was positively correlated to the tension variation but needle gauge (number of needles per inch of the circumference) was not or negatively to it.

Duru, Candan and Mugan (2015) evaluated the effect of machine speed and yarn tension independently on needle

displacement behavior for an industrial circular knitting machine. They observed that the needle displacement in both x and y co-ordination tended to increase as the yarn tension increased, irrespective of machine speed. Regarding machine speed they did not show any specific finding rather they highlighted on needle velocity which was higher at robbing back resulting greater needle displacement. However in this research work no observation was made for course length due to change in knitting parameters or needle displacement.

The present study was therefore conducted in an attempt to investigate the influence of operational speed on crucial knitting variables for a commercial production based circular knitting machine.

EXPERIMENTAL PROCEDURE

Source of Data

The major portion of the experimental work was carried out on a multi-feeder industrial circular knitting machine (Orizio, Johnan) of 24-gauge and 26-inch diameter (Figure 5) with a circumferential speed of 1.31 m/sec (Orizio Paolo S. p. A., n. d.). The Yarn delivery of this machine was ‘positive storage feed’ type where storage/feed wheels, driven by Quality Adjusting Pulley (QAP), were deployed for yarn pulling from the package and supplying to the needles. Yarn input tension and ‘on-machine’ course length data were recorded from the zone of yarn path immediately before the feeder ring eye (Figure 6).

Figure 5: Circular Knitting Machine (Orizio, Johnan)

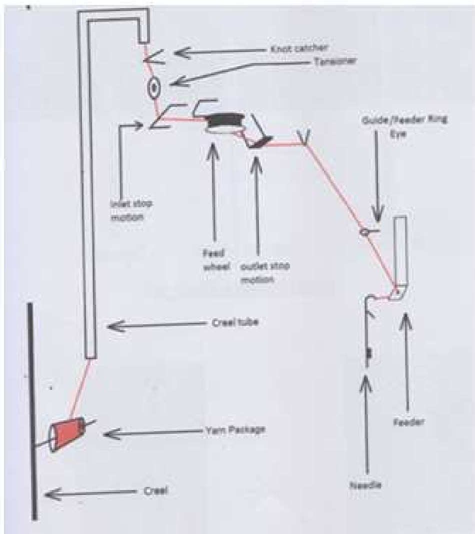


Figure 6: A Schematic Diagram of Yarn Path in a Knitting Machine with Positive Storage Feed

Spun Polyester yarns of four different counts were taken as the raw material whose mechanical properties were tested through TITAN Universal Strength Tester (Figure 7) following ASTM D2256-10(2015) (American Society for Testing and Materials, 2015). Some of these properties are mentioned in Table 1.

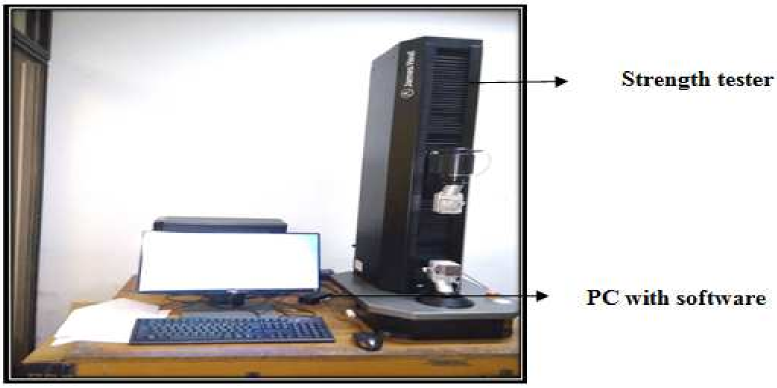


Figure 7: Titan5 Universal Strength Tester (Model 1410)

Table 1: Mechanical Properties of the Experimental Yarns Obtained Through TITAN Universal Strength Tester

Yarn → Mechanical Property ↓	Spun Polyester, (Count=23.62 Tex, Twist Per cm=8.14)	Spun Polyester, (Count=20.36 Tex, Twist Per cm=8.86)	Spun Polyester (Count=17.90Tex, Twist Per cm=9.54)	Spun Polyester (Count=14.91Tex, Twist Per cm=10.08)
Initial Modulus (cN/Tex)	139 (*cv*=4.5%)	139(*cv*=6%)	154 (*cv*=9%)	134(*cv*=5%)
Tenacity(cN/Tex)	13.77 (*cv*=4%)	13.60 (*cv*=4%)	13.69 (*cv*=9%)	13.17(*cv*=5%)
Extension at break (%)	12.12((cv=4.6%)	11.85(*cv*=3%)	11.47(*cv*=4%)	10.32(*cv*=2%)
Proportional Limit(as force value, i.e.cN)	48.50(*cv*=5%)	34.12 (*cv*=8%)	30.62(*cv*=9%)	28.22(*cv*=4%)

Knitting

Before taking any experimental reading the machine was run for around 30 minutes to heat it up to normal working condition. Plain Jersey fabric samples were then produced with different count of spun polyester yarn using same yarn delivery setting at positive storage feed device. The disc reading of 131 for QAP indicated feeding unit driving belt speed of 5.38m/sec (Orizio Paolo S. p. A., n. d.) though the yarn delivery rate might differ somewhat from the belt speed (Dias and Lanarolle, 2002). The samples were knitted at five different machine speed (changed through the inverter drive) for two different loop sinking depths (Figure 8-10) identified by stitch cam positions. The two cam positions, as obtained through adjusting the graduated knob, were selected so that the experimental results may be observed for two different zones of yarn input tension. It may be mentionable here that lower positioning of the stitch cam setting, i.e. lower cam setting point results lower yarn input tension (Lek-Uthai,1999). Average room temperature and relative humidity recorded during the experimental hours were around 29°C and 67% respectively.

Figure 8: Camboxes Around the Cylinder

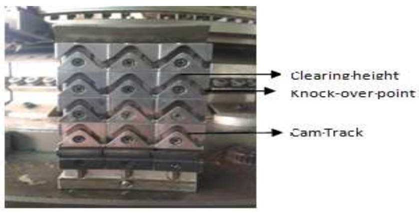


Figure 9: Cam Track/Race Inside Camboxes

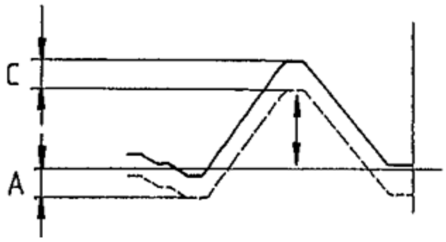


Figure 10: A Schematic Diagram of Changing Loop Sinking Depth through Cam Setting: C-Alterable Clearing Height; A-Alterable Knock-over Point (Iyer, Mammel and Schäch, 1995)

Data Collection During Dynamic Knitting

Machine speed, yarn input tension and corresponding yarn delivery/cylinder rev.(‘on-machine’ course length) were recorded at a particular feeder by MLT Wesco yarn meter (Figure 11) for two cam settings as indicated by uppermost scale readings, i.e., 0.6 and 0.7 of graduated knob . Dynamic coefficient of friction values were also obtained by Lawson-Hemphill’s Yarn Friction Meter (Figure 12) from running yarn. Collected data has been presented by Table 2 and Table 3.

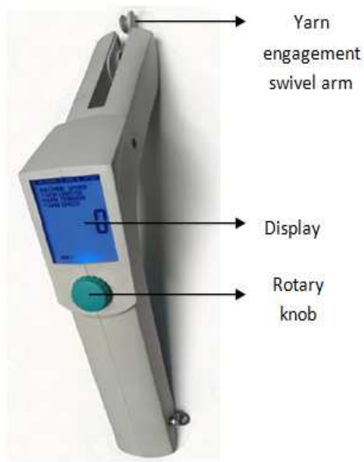


Figure 11: MLT Wesco Yarn Meter

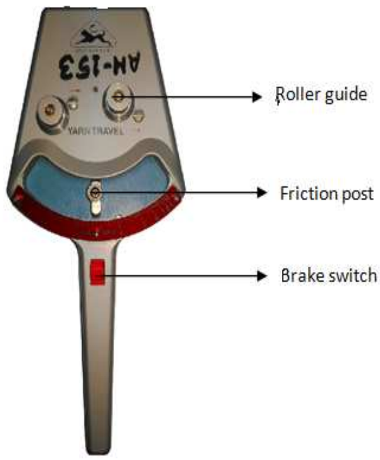


Figure 12: Lawson-Hemphill’s Hand-held Direct-reading Yarn Friction Meter

Table 2: Data on Machine Speed, Yarn Input Tension, ‘On-Machine’ Course Length and Dynamic Coefficient of Friction for Cam Setting Point of 0.6

23.62 Tex	Machine Speed(rpm)	5.5	10.5	15.9	21.2	26.4
	Machine Speed(m/sec)	0.19	0.363	0.549	0.733	0.912
	Average Yarn Input Tension(cN)	13.95	14.75	15.98	17.21	18.43
	Average Course Length(m) [Yarn delivery /Cylinder revolution]	5.265	5.272	5.279	5.285	5.29
	Dynamic Co-efficient of Friction	0.20-0.21	0.20-0.21	0.21-0.22	0.21-0.22	0.22-0.23
20.36 Tex	Machine Speed(rpm)	5.5	10.5	15.9	21.2	26.4
	Machine Speed(m/sec)	0.19	0.363	0.549	0.733	0.912
	Average Yarn Input Tension(cN)	13.51	14.39	15.19	17.38	18.3
	Average Course Length(m) [Yarn delivery /Cylinder revolution]	5.267	5.277	5.281	5.288	5.292
	Dynamic Co-efficient of Friction	0.20-0.21	0.20-0.21	0.21-0.22	0.21-0.22	0.22-0.23
17.90 Tex	Machine Speed(rpm)	5.5	10.5	15.9	21.2	26.4
	Machine Speed(m/sec)	0.19	0.363	0.549	0.733	0.912
	Average Yarn Input Tension(cN)	15.35	17.26	18.45	19.2	20.15

	Average Course Length(m) [Yarn delivery /Cylinder revolution]	5.255	5.26	5.264	5.27	5.275
	Dynamic Co-efficient of Friction	0.20-0.21	0.21-0.22	0.21-0.22	0.22-0.23	0.22-0.23
14.91 Tex	Machine Speed(rpm)	5.5	10.5	15.9	21.2	26.4
	Machine Speed(m/sec)	0.19	0.363	0.549	0.733	0.912
	Average Yarn Input Tension(cN)	11.43	13.1	13.61	14.75	15.82
	Average Course Length(m) [Yarn delivery /Cylinder revolution]	5.275	5.281	5.288	5.294	5.298
	Dynamic Co-efficient of Friction	0.19-0.20	0.20-0.21	0.20-0.21	0.20-0.21	0.21-0.22

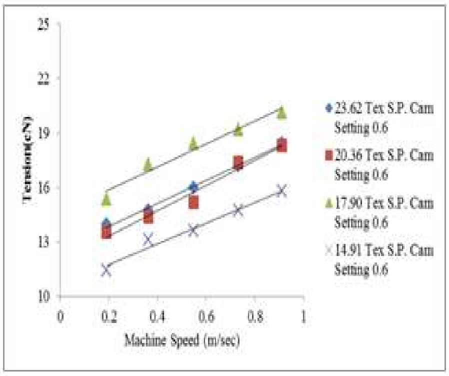
Table 3: Data on Machine Speed, Yarn Input Tension, 'On-Machine' Course Length and Dynamic Coefficient of Friction for Cam Setting Point of 0.7

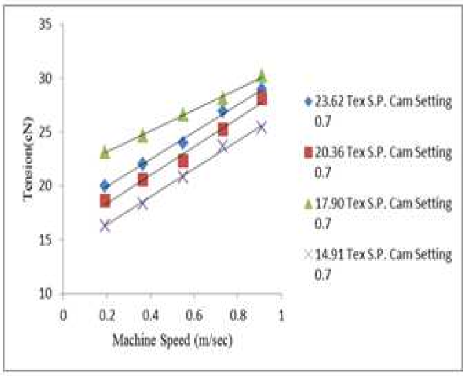
23.62 Tex	Machine Speed(rpm)	5.5	10.5	15.9	21.2	26.4
	Machine Speed(m/sec)	0.19	0.363	0.549	0.733	0.912
	Average Yarn Input Tension(cN)	20.01	22	23.98	26.93	28.92
	Average Course Length(m) [Yarn delivery /Cylinder revolution]	5.28	5.289	5.299	5.314	5.322
	Dynamic Co-efficient of Friction	0.22-0.23	0.22-0.23	0.23-0.24	0.23-0.24	0.24-0.25
20.36 Tex	Machine Speed(rpm)	5.5	10.5	15.9	21.2	26.4
	Machine Speed(m/sec)	0.19	0.363	0.549	0.733	0.912
	Average Yarn Input Tension(cN)	18.61	20.59	22.34	25.24	28.12
	Average Course Length(m) [Yarn delivery /Cylinder revolution]	5.277	5.291	5.3	5.315	5.325
	Dynamic Co-efficient of Friction	0.22-0.23	0.22-0.23	0.22-0.23	0.23-0.24	0.23-0.24
17.90 Tex	Machine Speed(rpm)	5.5	10.5	15.9	21.2	26.4
	Machine Speed(m/sec)	0.19	0.363	0.549	0.733	0.912
	Average Yarn Input Tension(cN)	23.15	24.63	26.59	28.12	30.25
	Average Course Length(m) [Yarn delivery /Cylinder revolution]	5.282	5.286	5.295	5.301	5.312
	Dynamic Co-efficient of Friction	0.22-0.23	0.23-0.24	0.23-0.24	0.24-0.25	0.24-0.25
14.91 Tex	Machine Speed(rpm)	5.5	10.5	15.9	21.2	26.4
	Machine Speed(m/sec)	0.19	0.363	0.549	0.733	0.912
	Average Yarn Input Tension(cN)	16.33	18.33	20.84	23.65	25.4
	Average Course Length(m) [Yarn delivery /Cylinder revolution]	5.29	5.305	5.315	5.324	5.335
	Dynamic Co-efficient of Friction	0.21-0.22	0.21-0.22	0.22-0.23	0.22-0.23	0.23-0.24

RESULTS & DISCUSSIONS

Effect of Machine Speed on Yarn Input Tension

From Figure 13 it may be observed that machine speed has a positive influence on yarn input tension. The regression analyses as shown in Table 4 and Table 5 reveal that a good correlation exists between machine speed and yarn tension. The value of R^2 was greater than 0.95 in each case indicating that more than 95% of the variation in the tension values can be explained by the explanatory variable, i.e. machine speed. Again the obtained p-values for slope parameter were always less than 0.05, revealing that the slope is statistically significantly different than zero based on 95% confidence level and the possibility of no relationship between machine speed and yarn tension can be excluded. Moreover using the regression equation yarn input tension may be predicted from machine speed and the standard error determines the limit of confidence for the forecasted value. As an example it may be estimated that for yarn of 23.62 Tex Spun Polyester a change of machine speed by 0.173 m/sec (05 rev/min for the experimental machine of 26 in. diameter) would result a change of yarn input tension by 1.09 cN for cam setting of 0.6 and 2.17 cN for cam setting of 0.7. The actual value of yarn input tension would be within +/-2 S_e of the predicted value based on 95% confidence. However it should be noted that the prediction is particularly valid for machine speed ranging from 0.19 to 0.912 m/sec.





(a) (b)

Figure 13: Machine Speed vs. Yarn Input Tension with Least Square Trend Line for Different Spun Polyester (S. P) Yarns at Different Cam Settings: (a) For Cam Setting Point of 0.6 and (b) for Cam Setting Point of 0.7

Table 4: Linear Regression Analysis between Machine Speeds (MS) and Yarn Input Tension (YIT) for Cam Setting Point of 0.6

Regression Summary	23.62 Tex	20.36 Tex	17.90 Tex	14.91 Tex
Multiple R	0.997882021	0.984357967	0.980696251	0.988042296
R Square	0.995768528	0.968960606	0.961765137	0.976227578
Standard Error	0.136003897	0.411172071	0.419403423	0.296698351
Intercept	12.60325671	11.94330137	14.59283693	10.58816836
Slope	6.299132303	6.936109622	6.350861073	5.740501706
t-Statistic for Slope	26.57015632	9.677363943	8.686911059	11.09939867
p-Value for slope	0.000116971	0.002342891	0.00321022	0.001566841
Regression Equation	YIT(cN)= 6.299132303*MS +12.60325671	YIT(cN)= 6.936109622*MS +11.94330137	YIT(cN)= 6.350861073*MS +14.59283693	YIT(cN)= 5.740501706*MS +10.58816836
Predicted approximate change in YIT(cN) for change in machine speed by 5 rpm or 0.173 m/sec	1.09	1.2	1.1	0.99

Table 5: Linear Regression Analysis between Machine Speed (MS) and Yarn Input Tension (YIT) for Cam Setting Point of 0.7

Regression Summary	23.62 Tex	20.36 Tex	17.90 Tex	14.91 Tex
Multiple R	0.997718053	0.993881501	0.998425147	0.998091632
R Square	0.995441313	0.987800438	0.996852773	0.996186906
Standard Error	0.281193778	0.48037274	0.181504804	0.265131857
Intercept	17.47547743	15.80989706	21.18973519	13.80149775
Slope	12.54554526	13.05078803	9.752939217	12.93866446
t-Statistic for Slope	25.59461304	15.58558522	30.82564167	27.99576047
p-Value for slope	0.000130811	0.000573987	0.0000750052	0.000100047
Regression Equation	YIT(cN)= 12.54554526*MS+ 17.47547743	YIT(cN)= 13.05078803*MS+15 .80989706	YIT(cN)= 9.752939217*MS+ 21.18973519	YIT(cN)= 12.93866446*MS+ 13.80149775
Predicted approximate change in YIT(cN) for change in machine speed by 5 rpm or 0.173 m/sec	2.17	2.26	1.69	2.24

When speed of a circular knitting machine increases, the belt speed of the positive feed system increases as well, this in turn results in higher yarn delivery from the feed wheel. Simultaneously knitting speed also increases so that the ratio of calculated yarn speed/unit time to the number of needles knitting/unit time remains constant and the purpose of positive feeding is fulfilled. Therefore the average yarn input tension is expected to remain unaffected if the machine speed

is changed for circular weft knitting with positive storage feeding. Through this experimental study it was found that yarn input tension is influenced by machine speed. The reason for such contradiction with the theoretical expectation may be attributed to the fact that the temporary increase of the depth of stitch draw is more at higher knitting speed due to the inertia force on the needle after the knitting point. Oinuma (1984) also pointed out this phenomenon when he investigated on end breakage rate due to knots of spun yarns during knitting. The dynamic coefficient of friction as measured through Lawson-Hemphil yarn friction meter during the experimental study also showed the evidence for rise in yarn tension due to change in machine speed as shown in Figure 14.

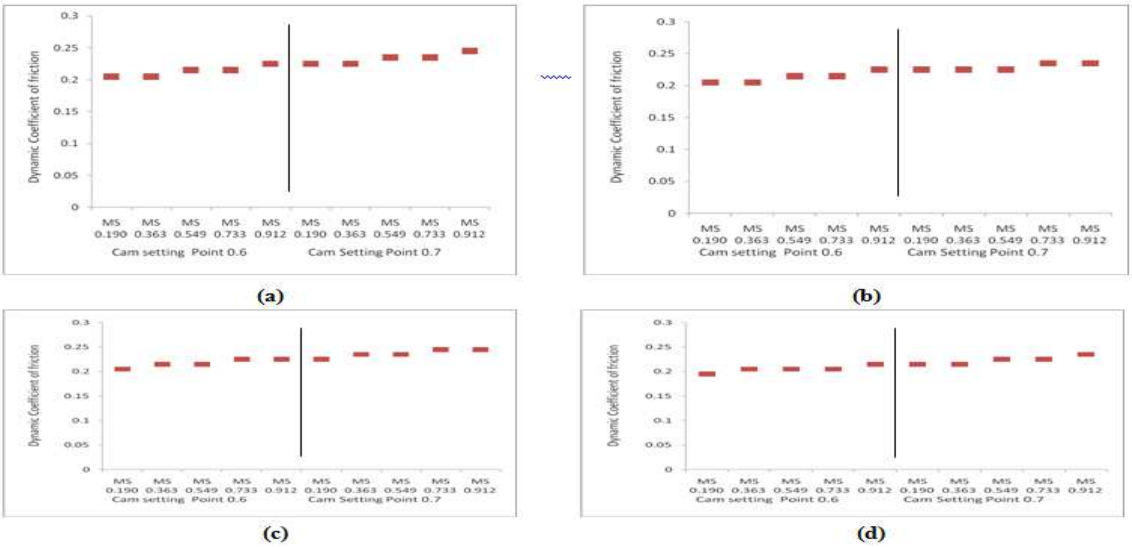
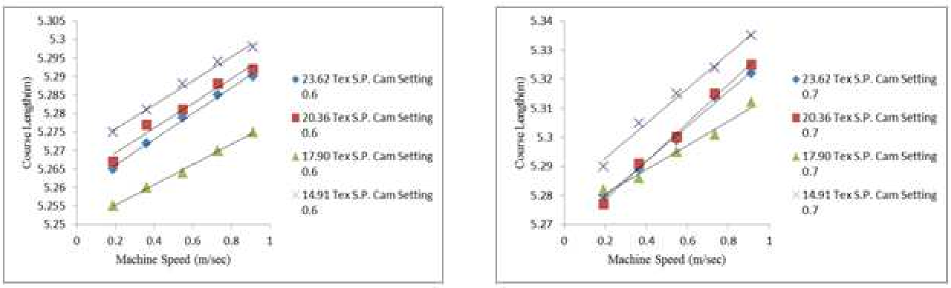


Figure 14: Values of Dynamic Coefficient of Friction at different Machine Speed (MS) for different Spun Polyester Yarns : (a) for 23.62 Tex (b) for 20.36 Tex, (c) for17.90 Tex and (d)for14.91 Tex

Effect of Machine Speed on 'On-Machine' Course Length

From Figure 15 it can be found that 'on-machine' course length, i.e. yarn length per cylinder revolution is influenced by machine speed. From the regression analysis, as shown in Table 6 and Table 7, it may be predicted that a change of machine speed by 0.173 m/sec, i.e., 5 rev/min. would results, for example, a change in 'on-machine' course length by 0.006m at cam setting point of 0.6 and 0.10m at cam setting point of 0.7 for 23.62 Tex spun polyester at same experimental machine setting.



(a) (b)

Figure 15: Machine Speed vs.' on-machine' Course Length with Least Square Trend Line for different spun Polyester (S.P.) Yarns at different Cam Settings: (a) for Cam Setting Point of 0.6 and (b) for Cam Setting Point of 0.7

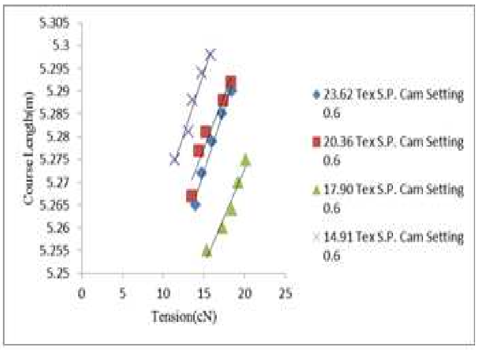
Table 6: Linear Regression Analysis for Machine Speed (MS) and 'On-Machine' Course Length (CL) for Cam Setting Point of 0.6

Regression Summary	23.62 Tex	20.36 Tex	17.90 Tex	14.91 Tex
Multiple R	0.997412294	0.985610144	0.998384754	0.996267397
R Square	0.994831284	0.971427355	0.996772118	0.992548727
Standard Error	0.000828912	0.00190742	0.000519472	0.000933436
Intercept	5.259124488	5.262551512	5.249657917	5.269329791
Slope	0.034720627	0.033579337	0.027561127	0.032526773
t-Statistic for Slope	24.02946022	10.0992837	30.43685272	19.99039175
p-Value for slope	0.000157957	0.002067659	0.0000779088	0.000273595
Regression Equation	CL=0.034720627 *MS+5.259124488	CL=0.033579337 *MS+5.262551512	CL=0.027561127 *MS+5.249657917	CL=0.032526773 *MS+5.269329791
Predicted approximate change in CL(m) for change in machine speed by 5 rpm or 0.173 m/sec	0.006 m	0.006m	0.005m	0.006m

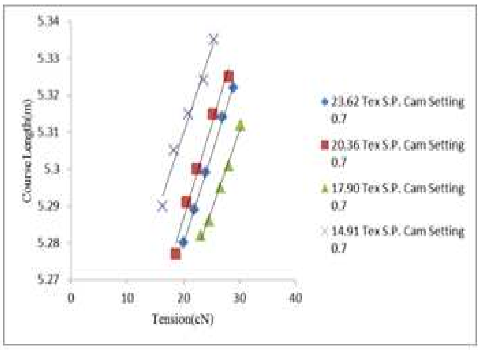
Table 7: Linear Regression Analysis for Machine Speed (MS) and 'On-Machine' Course Length (CL) for Cam Setting Point of 0.7

Regression Summary	23.62 Tex	20.36 Tex	17.90 Tex	14.91 Tex
Multiple R	0.996159049	0.997208016	0.989950938	0.994497643
R Square	0.992332851	0.994423828	0.98000286	0.989025562
Standard Error	0.001750369	0.001640105	0.00195741	0.002094131
Intercept	5.267768677	5.265269284	5.272470181	5.280823767
Slope	0.06012254	0.066127987	0.041372076	0.060022267
t-Statistic for Slope	19.70481493	23.1301422	12.12524029	16.44270373
p-Value for slope	0.000285589	0.00017702	0.00120744	0.000489551
Regression Equation	CL=0.06012254 *MS+5.267768677	CL=0.066127987 *MS+5.265269284	CL=0.041372076 *MS+5.272470181	CL=0.060022267 *MS+5.280823767
Predicted approximate change in CL(m) for change in machine speed by 5 rpm or 0.173 m/sec	0.010m	0.011m	0.007m	0.010m

When yarn input tension increases through cam setting or machine speed at fixed positive storage feed setting, the corresponding yarn delivery as measured by a yarn length and rate meter also increases (Figure 16). This is due to the fact that yarn becomes stretched due to tension as yarn delivery from the feed system remains unchanged (Lek-Uthai, 1999; Dias and Lanarolle, 2002).



(a)



(b)

Figure 16: Yarn Input Tension vs. 'On-Machine' Course Length with Least Square Trend Line for Different Spun Polyester (S. P) Yarns at Different Cam Settings: (a) for Cam Setting Point of 0.6 and (b) for Cam Setting Point of 0.*7

To find out numerically how yarn delivery /machine revolution, i.e. on-machine course length could be affected by yarn input tension a summarized table (Table 8) from regression analysis has been generated.

Table 8: Selected Regression Data for Yarn Input Tension (YIT) and 'On-Machine' Course Length (CL) as Found Using Cam Setting Point of 0.6 and 0.7

Cam Setting Point	Spun Polyester Yarn Count (Tex)	Some Regression Summary Output				Predicted Change In Course Length (M) For A Unit Change In Yarn Input Tension(Cn)
		R Square	Intercept	Slope	Regression Equation	
0.6	23.62	0.982883792	5.190375418	0.005467168	CL=0.005467168*YIT+5.190375418	0.0055
	20.36	0.931697644	5.207475446	0.00466704	CL=0.00466704*YIT +5.207475446	0.0047
	17.90	0.949600625	5.189686518	0.004154047	CL=0.004154047*YIT+5.189686518	0.0041
	14.91	0.966691248	5.211275038	0.00552503	CL=0.00552503*YIT +5.211275038	0.0055
0.7	23.62	0.998797343	5.183907809	0.004796955	CL=0.004796955* YIT +5.183907809	0.0047
	20.36	0.985049347	5.18642017	0.005012177	CL=0.005012177* YIT +5.18642017	0.0050
	17.90	0.991833953	5.182083767	0.004260819	CL=0.004260819* YIT +5.182083767	0.0043
	14.91	0.991833953	5.21747972	0.004606422	CL=0.004606422* YIT +5.21747972	0.0046

It can easily be understood that though significant variation in yarn input tension values were observed for change in cam setting point (Table 2 and Table 3), the rate of change in course length with respect to yarn tension is expected to be almost similar. As found through this experimental work, while knitting with spun polyester yarns, a change in yarn input tension by 1 cN might turn to a change of around 0.005m in 'on-machine' course length (Table 8). It should be noted that yarn input tension was within the proportional limit [as mentioned in Table 1] in each case during the experimental hours. It may also be pointed out that the comparatively higher modulus of 17.90 Tex spun polyester yarn might be, somewhat, responsible for lesser slope value in its YIT-CL regression equation.

CONCLUSIONS

Machine speed is the most preferable choice for a knitter when he/she aimed to get higher production rate. But as the knitter has to ensure product quality too he/she should have evaluated the possible influence of machine speed over yarn input tension as well as course length before running it at a particular speed. In the research work correlation of machine speed with yarn input tension and 'on-machine' course length were evaluated independently through regression analysis. Yarn input tension was positively influenced by machine speed and the maximum forecasted change in tension was around 2 cN for change of machine speed by 0.173 m/sec, i.e., 5 rev/min for the experimental circular knitting machine at a fixed positive feed setting. Consequently a maximum change in 'on-machine' course length of around 0.010m or around 2% was also predicted for similar alteration in machine speed. However such variation may be overlooked if the product quality does not fall beyond the acceptable limit. Therefore an extensive study for a wide variety of yarn and yarn delivery rate is suggested to depict a more expanded figure over the influence of machine speed on yarn input tension and course length.

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